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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MARKETING CLAY

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BY

PAUL M. TYLER

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MARKETING CLAY[1]

By Paul M. Tyler[2]

Description and Properties

A great variety of substances that differ widely in chemical, mineralogical, and physical properties are loosely linked under the generic term "clay", but for the average man all that matters is whether a given material can be sold or used profitably. So-called "clays" range in texture from true clays and allied minerals that are typically "fat" or sticky to fine sand. Sand and other strictly silicious materials, such as tripoli and diatomite, are not clays in any sense; but many commercial clays are strictly loams, for they are intermediate in texture and always contain a mixture of minerals, though the term "loam" has little commercial usage except in foundry work. Even pure kaolinite, ordinarily considered the typical "clay substance", recently was found to exist as three distinct minerals; and each of these, in turn, exhibits variations in particle size and other physical attributes. Probing with the X-ray and employing other modern tools and techniques, scientists are tracing the patterns of molecules and finding chemical and physical phenomena that seem to disclose the causes for the markedly different behavior of the various aluminum silicates with varying proportions of combined and adsorbed water that are the essential ingredients of commercial clays; but rule-of-thumb definitions and enforced reliance upon empirical tests of actual samples still hold sway. In addition to the hydrated simple silicates of aluminum, almost all clays contain quartz, feldspar, and mica with varying amounts of organic matter and, in addition, other impurities - such as iron, manganese, and titanium oxides - that may discolor them sufficiently to render them unfit for certain important uses. The white clays are generally the purest, but no two clays are really alike, and great care must be exercised to maintain a reasonable uniformity in successive shipments even from the same deposit.

High-grade clays, when properly prepared for market, sell for $6 to $60 or more a ton, while many clays are not worth taking out of the ground. Careful laboratory or actual industrial-plant tests have to be made before the suitability of a clay for a specified use can be determined definitely;

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but such tests cost money, and consideration may be given, first, to simple characteristics that can be noted by even an inexperienced person. Chief among these are color, texture, and general behavior when moistened with water. Refractoriness, or the ability to withstand high temperature, affords another broad base for classification but cannot be determined easily in an ordinary fire or even in a blacksmith's forge. Common sense dictates that no deposit is worth investigating unless it bears promise of being capable of yielding a substantial tonnage of relatively uniform quality, but, conversely, no deposit is worth exploring as to its size and character unless it shows promise of yielding clay of a quality that might be mined profitably at that particular location. Low-grade clays, even if suitable for making common brick or other heavy-clay products, are of no value unless they lie within easy reach of populous communities that may provide a market for the products, and then only in conjunction with a suitable plant for converting them into salable products at the pit.

Color is the most readily distinguishable property and, fortunately, one of the most important from the viewpoint of price. Generally speaking, no clay is worth over $3 a ton unless it is almost white or becomes white when strongly heated. Exceptions to this rule are ochers and other earthy pigments - recognizable because of their uniform, pleasing color - bentonite, and certain other highly plastic, fine-grained clays, and fuller's earth. On the other hand, there are white clays that have little value because their texture is not good, because they do not work well when wetted, because they contain too many impurities, or because, either in raw or fired condition, they are not quite white enough. White clays are generally classed as "china clay" or "kaolin", the former term implying that they are often used in making china or porcelain, although in the United States the largest use of white clays is for paper making and large quantities are consumed in rubber, paints, and miscellaneous uses. Chemical analysis usually shows not more than 50 or 60 percent silica nor more than 2 percent alkalies, but cannot be relied upon to forecast commercial value as there are good white clays that do not have the requisite physical properties even though their composition falls within the chemical limits of a high-grade clay. A rough test of whiteness is to make a mark on high-quality calendared paper such as used in the better-class magazines and books. Particle size, plasticity, firing behavior, and other properties, however, also enter into the appraisal of a white clay but are not so easily evaluated by an amateur or without suitable equipment.

Texture is essentially the same thing as particle size. A rough test of the fineness is to get the clay into suspension, generally by shaking it for a long time with water, and then to put the mixture through suitable sieves or bolting cloth. This test fails to reveal the presence of silt, nor does it give information as to ultimate particle size of really fine-grained clays, but it gives information of great practical value. Material that will not pass through a screen having about 160 openings per linear inch ordinarily would have to be removed before the

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clay could be used for any purpose except making common brick or other relatively low-grade products. Even in manufacturing heavy-clay products, the presence of large stones is undesirable and, if the stones are limestone or other material that might disintegrate when fired in the kiln, the coarse material may have to be removed. Simply to determine the presence of small gritty particles, no better test has been found than to try a little of the clay between the teeth.

Plasticity is one of the most important properties of clay, especially for clay used in pottery and fired products of all kinds. It is this property that enables properly moistened clay to be kneaded or pressed into a desired shape and otherwise handled without rupturing. Closely related to plasticity is binding power, or the ability to unite with nonplastic material and water to form a plastic paste. Clays with high binding power are "fat" clays; "loan" clays lack this power, often because they already are mixed with sand, but often, also, because of inherent differences in the clay substance. Primary clays, especially from deep mines, are characteristically less plastic than sedimentary or transported clays from shallow deposits. Particle size, particle shape, and adsorbed salts all come into the picture. Many ball clays and refractory bond clays, for example, not only are quite fine-grained but are mixed with lignite, and the probable influence of organic impurities is further indicated by the fact that additions of tannin tend to improve the plasticity of clay.

To an undetermined extent, the commercial characteristics of a given clay are dictated by the nature of the predominant clay minerals, chief of which are (1) kaolinite, (2) beidellite, (3) montmorillonite, (4) halloysite, and (5) a sericitelike mineral. Kaolinite is the essential constituent of kaolins, ball clays, refractory underclays, certain flint clays, and a few sedimentary clays, but, contrary to common opinion, it is not present in all clays. It is more refractory than other clay minerals and typically not quite so fine-grained.

Commercial Classifications

Common clays, such as can be used only for heavy-clay products, are mined and fabricated at the pit. The clay itself constitutes only a small fraction of the value of the finished product, and before a deposit of such clay can be exploited an expensive plant has to be built to work it up into products that can be marketed. Ordinarily, only the higher-priced clays can be marketed as clay, and the tendency is, more and more, to process and refine even the clays that are sold in the raw or unfired condition as demand for better quality grows ever more insistent. Statistics of production, by States, prices, and distribution of sales by consuming industries, are published annually for the leading types of merchant clays by the Bureau of Mines in the Minerals Yearbook. The principal types of merchant clays are kaolin or china clay, ball clay, slip clay, fireclay, stoneware clay, bentonite, and fuller's earth.

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Clay used by the producer in making clay products is ordinarily not reported by the Bureau of Mines, as it does not come on the market as clay, but there are miscellaneous clays that do not come under any of the foregoing classifications.

Kaolin or china clay. - In Georgia, the leading producing State, clays have been classified as follows: (1) soft; (2) semihard; (3) hard; (4) flint; (5) bauxitic; and (6) bauxite. All gradations exist between the soft, the semihard, and the hard kaolins, but there is a sharp difference between the hard kaolins and the flint kaolins, the latter being used at present only for the manufacture of refractories and consequently is indistinguishable commercially from fireclay. The production of kaolin or china clay in the United States jumped to 638,939 short tons valued at $4,537,738 in 1936, which includes 51,932 tons of Georgia flint kaolin used for refractory purposes valued at $2.54 a ton compared with an average of $7.52 a ton for other classes of Georgia kaolin. Formerly, English clays were used largely in this country, but improved processing has made domestic clays accessible for nearly all leading uses, with the result that continued use of foreign clays is to a large extent dependent upon geographical location or long-established buying habits. The paper industry absorbs about two-thirds of the total sales of domestic kaolin, while the rubber and ceramics industries each take about 15 percent. Residual kaolins from North Carolina are used chiefly in the manufacture of whiteware. The cream sedimentary clays of South Carolina are employed largely in paper and as fillers in rubber goods and oilcloth and to a limited extent in ceramic products. The white clays of Georgia and South Carolina are used for similar purposes and also for coating paper. Florida clays, somewhat more plastic than those from other localities, are used in whiteware, floor and wall tile, and electrical porcelain, but are not regarded as paper clays.

Ball clay. - Ball clays are highly plastic, strong, and white to cream in color. Geologically they represent the finest of the pure clay substance that remains suspended for the longest time in lakes or swamps; often they contain a little lignite. Toughness is a characteristic property, and the presence of adsorbed salts or electrolytes is indicated. Though mainly kaolinitic in character, they usually also contain beidellite. Ball clays also differ from kaolins in that their average particle size is measurably smaller. Domestic ball clay is mined principally in Kentucky and Tennessee, although minor amounts so classed are produced in New Jersey, Maryland, Missouri, and Illinois. They are used chiefly in white earthenware and porcelain but are employed also in floor and wall tile, electrical porcelains, certain glass refractories, and graphite crucibles, chiefly mixed with china clay in the body as a bonding agent and to impart plasticity and, in refractory mixes, to make them workable. Production in 1936 rose to 101,324 short tons valued at a little less than $7 a ton.

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Slip clay. - Slip clays are fine-grained and somewhat similar to ball clays, except that they contain a high percentage of iron and manganese, so that they melt to greenish or brown glass at relatively low temperatures. The use of slip clays for glazing stoneware is decreasing, as they are being displaced for this purpose by artificial white glass. So-called "slip" clays are mined in the United States only in New York, Pennsylvania and (occasionally) Michigan. Although separately reported by the Bureau of Mines in previous years, henceforth they will be included in the classification "miscellaneous clays." At present they are employed principally for binding abrasive wheels, although minor quantities are still used for glazing pottery, tile, and other fired products. The quantity produced has become quite small, in recent years rarely exceeding 5,000 tons annually valued, on the average, at $6 or more per ton.

Fireclay. - Fireclays withstand high temperature and usually are not fusible below about 3,000°F. (cone 27 or 28). In collecting statistics, the Bureau of Mines will attempt later to distinguish between (a) plastic fireclays, (b) flint clays, and (c) high-alumina or burley clays. Although the main use of fireclays is for refractories of various kinds, chiefly firebrick, many of the miners of these clays find markets for a portion of their output in other industries, including some purposes for which other kinds of clay might be equally suitable. In short, the term "fireclay" is employed rather loosely and is not confined strictly to refractory clays, nor does it include all clays used in making refractories.

Although fireclay occurs in all but about a dozen States and is mined in at least 30, Pennsylvania, Ohio, Missouri, Kentucky, and California together contribute over 75 percent of production, about one-third of the total coming from Pennsylvania alone. Production of fireclay in 1936 was 2,471,575 tons with an average value of $2.48 a ton.

Stoneware clay. - Stoneware clays are produced principally in Ohio and Illinois and are used not only for stoneware but also for yellow ware, art ware, earthenware, and oven for terra cotta. The classification obviously is arbitrary and overlaps that for fireclay.

Bentonite. - Bentonites are "soapy" clays composed of weathered and altered volcanic ash. They are characterized by an extraordinary capacity to take up many times their own volume of water (adsorption). Their chief use is for oil-well drilling muds to maintain suspensions, but their thickening and suspending properties are utilized in many other industries, and substantial quantities are employed in foundries for rejuvenating molding sand and as a core wash. Most of the activated earths employed for bleaching oils are acid-treated bentonites. Another use of great practical importance, though not constituting a regular outlet for much tonnage, is for sealing dams and for rendering water-bearing gravels and seamy rock impervious. Probably the most typical bentonite is found near Belle Fourche, S. Dak., and in an adjoining area in eastern Wyoming,

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although it occurs in at least a dozen States and commercial shipments were reported in 1936 from eight States. Shipments as reported in 1936 aggregated 291,625 tons having an average value of $5.37 a ton. This included nearly 100,000 tons of "rotary mud", a low-grade product worth less than $2 a ton. Better grades of bentonite fetched from $8 to $15 a ton and up to $25 a ton for air-floated material.

Fuller's earth. - Virtually all clays have some bleaching power, but only those commercially used for decolorizing or bleaching oils and other liquids are classed as fuller's earth. This is a peculiar type of clay having high absorbent power. The color is variable, though generally light, and when dried fuller's earth often adheres strongly to the tongue, but neither chemical composition nor physical appearance can be depended upon as a clue to its classification, which is strictly utilitarian. Most fuller's earth as well as bentonites contain montmorillonite. However, any nonplastic clay that is porous, mixes well with water, and absorbs oil should be investigated for possible use as fuller's earth. Over 90 percent of the domestic fuller's earth sold is used for refining petroleum products; 5 to 7 percent is used for clarifying, bleaching, decolorizing, or filtering animal and vegetable oils; and an almost negligible amount, frequently less than 1 percent, is used for miscellaneous purposes. Production of fuller's earth in 1936 was 230,814 short tons valued at an average of $9.81. Florida and Georgia ordinarily contribute over 60 percent of the total production.

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Tyler, Paul M., Clay: Inf. Circ. 6155, Bureau of Mines, 1935, 66 pp.

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TABLE 1. - Clay sold by producers in the United States in 1936, by kinds and uses, in short tons

Use	Kaolin	Ball clay	Slip clay	Fireclay	Stoneware clay	Bentonite	Miscellaneous clay	Total
Pottery and stoneware:								
Whiteware, etc.	52,196	68,801	-	1,262	-	-	-	122,259
Chemical stoneware	-	1,298	-	22,418	669	-	-	24,385
Stoneware	-	-	-	1,511	20,663	-	-	22,174
Art pottery	407	444	-	914	1,576	-	35	3,376
Flower pots	-	-	-	-	4,142	-	2,147	6,289
Slip for glazing	-	482	671	-	-	-	-	1,153
	52,603	71,025	671	26,105	27,050	-	2,182	179,636
Tile, high-grade	13,955	18,109	176	4,453	24	-	1,133	37,850
Kiln:								
Saggers, pins, stilts	2,220	868	-	38,438	-	-	-	41,526
Wads	-	-	-	10,531	-	-	41	10,572
	2,220	868	-	48,969	-	-	41	52,098
Architectural terra cotta	-	4,735	-	8,566	4,575	-	228	18,104
Paper:								
Filler	322,970	2,500	-	716	-	-	378	326,564
Coating	57,056	-	-	-	-	-	-	57,056
	380,026	2,500	-	716	-	-	378	383,620
Rubber	72,712	-	-	1,205	-	-	-	73,917
Linoleum and oilcloth	1,620	1,848	-	8,179	-	-	-	11,647
Paints:								
Filler or extender	10,429	375	-	-	-	-	384	11,188
Kalsomine	3,233	-	-	1,270	-	-	-	4,503
	13,662	375	-	1,270	-	-	384	15,691
Cement manufacture	26,304	578	-	2,322	-	520	23,021	52,745

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TABLE 1. - Clay sold by producers in the United States in 1936, by kinds and uses, in short tons (Cont'd)

Use	Kaolin	Ball clay	Slip clay	Fireclay	Stoneware clay	Bentonite	Miscellaneous clay	Total
Refractories:								
Firebrick and block	43,556	600	-	1,399,401	-	-	-	1,443,557
Bauxite, high-alumina brick	-	-	-	7,962	-	-	-	7,962
Fireclay mortar	1,674	100	-	244,194	-	-	800	246,768
Clay crucibles	-	-	-	356	-	-	-	356
Glass pots	200	-	-	583	-	-	-	783
Other glass refractories	258	-	-	6,284	-	-	-	6,542
Zinc retorts and condensers	-	-	-	14,200	-	-	-	14,200
Foundries, steelworks	4,469	30	-	474,297	-	47,985	37,577	564,358
	50,157	730	-	2,147,277	-	47,985	38,377	2,284,526
Miscellaneous:								
Rotary drilling mud	-	-	-	-	-	140,030	21,348	161,378
Filtering and decolorizing oils (activated earths)	-	-	-	-	-	90,704	-	90,704
Artificial abrasives	-	44	2,770	1,055	467	-	-	4,336
Asbestos products	401	-	-	1,254	-	-	-	1,655
Chemicals	3,039	-	-	-	-	-	-	3,039
Enameling	30	100	-	-	-	-	-	130
Plaster and plaster products	3,675	-	-	958	-	-	1,568	6,201
Heavy clay products	2,338	-	-	131,226	3,200	-	169,062	305,826
Other uses	16,197	412	-	51,544	1,160	12,386	17,626	99,325
	25,680	556	2,770	186,037	4,827	243,120	209,604	672,594
Total, 1936	638,939	101,324	3,617	2,435,099	36,476	291,625	275,348	3,782,428
1935	523,656	96,260	4,316	1,903,027	35,364	191,133	169,714	2,923,470

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Buyers of Clay

Dealers in china clay, paper clay, and ball clay

Artex Mining Corporation, P. O. Box 766, Beaumont, Tex.
Balfour, Guthrie & Co., 351 California St., San Francisco, Calif.
Chas. B. Chrystal Co., Inc., 13 Park Place, New York, N. Y.
Edgar Bros. Co., Metuchen, N. J.
Enterprise White Clay Co., 139 So. 3rd St., Philadelphia, Pa.
Golding Sons Co., Trenton, N. J.
Hammill & Gillespie, Inc., 225 Broadway, New York, N. Y.
Joseph Dixon Crucible Co., Jersey City, N. J. (ball clay).
Minerals & Insulation Co., 139 Spring St., New York, N. Y.
Moore & Munger, 33 Rector St., New York, N. Y.
Pacific Coast Talc Co., 2149 Bay St., Los Angeles, Calif.
Paper Makers Chemical Co., Easton, Pa.
John E. Richardson & Co., Boston, Mass.
L. A. Salomon & Bro., 216 Pearl St., New York, N. Y.
Thomas H. Sandt & Sons Co., East Liverpool, Ohio.
R. T. Vanderbilt Co., Inc., 230 Park Ave., New York, N. Y.
United Clay Mines Corporation, Trenton, N. J.
Whittaker, Clark, & Daniels, Inc., 245 Front St., New York, N. Y.
C. K. Williams & Co., 13th St. and Bushkill Creek, Easton, Pa. (also ochers, etc.).
Wishnick, Tumpeer, Inc., 253 Front St., New York, N. Y.

Bentonite

American Colloid Co., 365 W. Superior St., Chicago, Ill.
Barnsdall Tripoli Co., Seneca, Mo.
California Talc Co., 837 Jackson St., Los Angeles, Calif.
Eastern Clay Products Co., 678 Ellicott Sq., Buffalo, N. Y.
Humble Oil & Refining Co., P. O. Box 2180, Houston, Tex.
Industrial Chemical Sales Co., Inc., 1333 New York Central Bldg., New York, N. Y.
Industrial Minerals & Chemical Co., Berkeley, Calif.
Geo. F. Pettinos, Inc., 1206 Locust St., Philadelphia, Pa.
F. E. Schundler & Co., Inc., 606 Railroad St., Joliet, Ill.
Standard Oil Co. of Indiana, 910 So. Michigan Ave., Chicago, Ill.

Fireclay

Federal Foundry Supply Co., 4600 East 71st St., Cleveland, Ohio.
General Refractories Co., 104 South 16th St., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
United Clay Mines Corporation, 107 Oakland Ave., Trenton, N. J.

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Fuller's earth (bleaching clays)

The more important consumers of fuller's earth are among the petroleum-refining companies whose names can be found in various directories. The following is an incomplete list of edible-oil refining concerns, dealers, and other possible buyers:

Armour & Co., Union Stock Yards, Chicago, Ill.
Attapulgus Clay Co., 260 So. Broad St., Philadelphia, Pa.
Braun Corporation, 363 New High St., Los Angeles, Calif.
Chas. B. Chrystal Co., 13 Park Place, New York, N. Y.
Corn Products Refining Co., 17 Battery Place, New York, N. Y.
Cudahy Packing Co., 111 West Monroe St., Chicago, Ill.
Dabrol Products Corporation, Chicago, Ill.
Gold Dust Corporation, 44 Beaver St., New York, N. Y.
Hammill & Gillespie, Inc., 225 Broadway, New York, N. Y.
J. L. Hopkins & Co., 135 William St., New York, N. Y.
Industrial Chemical Sales Co., Inc., 230 Park Ave., New York, N. Y.
International Vegetable Oil Co., Atlanta, Ga.
Lever Bros. Co., Cambridge, Mass.
Pomeroy & Fischer, Inc., 95 Madison Ave., New York, N. Y.
Procter & Gamble Co., Cincinnati, Ohio.
L. A. Salomon & Bro., 216 Pearl St., New York, N. Y.
Seguin Cotton Oil Co., Seguin, Tex.
Swift & Co., Chicago, Ill.
Wilson & Co., Chicago, Ill.

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